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## Glenn Safety Manual – Chapter 18

# Explosives, Propellants, and Pyrotechnics

*Approved by: QS/Chief, Safety and Health Division*

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**NASA - Glenn Research Center  
Cleveland, OH 44135**

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### Change Record

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C	6/24/2016	6/24/2021	16-001	Revision required to address audit findings from the 2014 Institutional, Facilities, Operations (IFO) audit and the REDAA analysis of GRC documents.

**\*\*Include all information for each revision. Do not remove old revision data. Add new rows to table when space runs out by pressing the tab key in the last row, far right column.**

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## Chapter 18—Explosives, Propellants, and Pyrotechnics

*NOTE: The current version of this chapter is maintained and approved by the Safety and Health Division (SHeD). The last revision date of this chapter was June 2016. The current version is located on the Glenn Research Center intranet within the BMS Library. Approved by Chief of Safety and Health Division.*

### 1.0 PURPOSE

This document provides a uniform set of standards for all NASA Glenn Research Center (GRC) installations involved in explosives handling or processing, and it complies with the cardinal principle for explosive safety: expose the minimum number of people to the smallest quantity of explosives for the shortest period consistent with the operation being conducted.

### 2.0 APPLICABILITY

This chapter is applicable to all GRC facilities at Lewis Field (LF) and Plum Brook Station (PBS) engaged in the handling, storage, transportation (onsite or offsite), or testing of explosives or of assemblies containing explosives. It provides guidance on procedures for operations involving explosives, propellants, and pyrotechnics and the safe management of such operations. It also provides guidance for the storage or handling of energetic liquids used for static test-stand operations. This chapter does not govern the bulk storage of hazardous gases used for standard industrial purposes (e.g., medical or welding) or for non-propellant systems involving liquid oxygen and liquid hydrogen. For these materials and systems, follow appropriate Occupational Safety and Health Administration (OSHA), National Fire Protection Association (NFPA), ASTM International (ASTM MNL 36, Safe Use of Oxygen and Oxygen Systems), American National Standards Institute/American Institute of Aeronautics and Astronautics (ANSI/AIAA G-095-2004, Guide to Safety of Hydrogen and Hydrogen Systems), and NASA regulations.

In this chapter, all mandatory actions (i.e., requirements) are denoted by statements containing the term “shall.” The terms “may” or “can” denote discretionary privilege or permission, “should” denotes a good practice and is recommended, but not required, “will” denotes expected outcome, and “are” or “is” denotes descriptive material.

### 3.0 BACKGROUND

The requirements of this chapter are derived from NASA Procedural Requirement (NPR) 8715.3C, NASA General Safety Program Requirements and NASA Standard (NASA-STD)-8719.12, Safety Standard for Explosives, Propellants, and Pyrotechnics.

### 4.0 POLICY

It is GRC policy to ensure that qualified personnel control explosives from acquisition through disposal. All research involving explosives, propellants, or pyrotechnics requires a Safety Permit. Only individuals who are certified in explosive operations in accordance with NASAs policies, who understand the potential hazards, and who have acquired the skills necessary to carry out their individual responsibilities safely will be involved in the use and handling of explosives. See Section 6.5 for training requirements. The GRC shall follow the requirements of NASA-STD-8719.12.

#### 4.1 Measurement and Verification

Compliance with the responsibilities and requirements of this chapter are measured and verified through the use of programmatic self-assessments, regulatory and agency audits, and internal field inspections and surveys.

### 5.0 RESPONSIBILITIES

#### 5.1 User's

It is the user's responsibility to ensure that, prior to conducting any operation involving explosives, all of the following requirements are met:

The installation (LF or PBS) has adequate facilities to store, handle, or test devices or materials that are classified as 1.1, 1.3, 1.4, 1.5 or 1.6 explosives. (See Section 6.8.1 for definitions related to explosive classifications.)

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The area safety committee chair is contacted first to discuss the nature and extent of the hazard to Center personnel, facilities, equipment, the community, and the environment before the user orders or takes delivery of any explosive material.

During the Safety Permit application process, the area safety committee is provided with all necessary documentation to verify compliance with NASA Headquarters requirements for handling explosives, including site and construction plans (required if more than laboratory-scale quantities are involved), any approved waivers to existing policies or procedures for handling explosives, hazard assessment form (NASA GRC-923A), applicable drawings, schematic diagrams, and standard operating procedures (SOPs) for explosive handling and operational test procedures to ensure that explosives are received, stored, handled, tested, and disposed of in a safe manner.

GRC organizations having oversight are properly informed of the expected delivery date. This includes the Safety and Health Division (SHeD), the Logistics and Technical Information Division (LTID), and the Office of Protective Services (OPS).

The GRC Chemical Hygiene Officer of SHeD shall be contacted prior to procuring explosives, propellants, or pyrotechnics.

## **5.2 Supervisor**

In coordination with the GRC ESO, ensures adequate facilities exist to safely store, handle, or test explosives or explosive devices. Supervisor shall ensure their employees handling explosives are knowledgeable, receive adequate training on explosives, and are certified to handle explosives through training provided by through the System for Training, Education, and Resources for NASA (SATERN).

Ensure adequate personal protective equipment (PPE) is available and used properly per GSM Chapter 15 – Personal Protective Equipment, if required. A job hazard analysis conducted per GSM Chapter 33 – Job Hazard Analysis shall be completed and will assist supervisors in selecting the proper PPE.

All personnel handling explosives are trained on specific SOPs and test procedures unique to the explosives being handled.

A current explosives inventory is maintained and available in the area where explosives are stored. This inventory shall be provided to the GRC ESO on an annual basis when requested.

Submits a Facility Explosive Site Plan when applicable per the site plan requirements detailed in this Chapter.

## **5.3 Area Safety Committee Chair**

The Area Safety Committee Chair associated with the geographical location of the explosive activity shall be notified in advance of the planned use of explosives in that area. For all new Safety Permits, the Chair may request that a preliminary meeting be held with the applicable Area Safety Committee to discuss an overview of the planned project and overall hazards anticipated. The Area Safety Committee may then identify safety problems related to site planning or storage requirements resulting from the initial meeting and require that these problems be resolved in the Safety Permit hazard analysis and related documentation at the time of submittal. Prior to project or task operation, a full Area Safety Committee review is required to ensure that all hazards are adequately addressed. For requirements related to Safety Permits, refer to Chapter 1A of the Glenn Safety Manual.

## **5.4 Explosives Safety Officer (ESO)**

The ESO shall have overall responsibility for ensuring that storage, handling, and testing of explosives—or devices containing explosives—comply with Federal, State, local, and NASA requirements as described in this chapter, including participation in the review and approval of site and construction plans and in the design of explosive storage, handling, and testing facilities. NPR 8715. 3C, Chapter 3, paragraph 3.11.4, provides a full description of ESO responsibilities. The ESOs at LF and PBS shall be appointed by the Director of Safety and Mission Assurance. The ESOs shall have sufficient knowledge and NASA training, as determined by the Chief of SHeD, to manage all aspects of the explosive safety program.

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## **6.0 REQUIREMENTS**

### **6.1 Facility Site and Construction Plans (NASA-STD-8719.12, Section 4.25)**

#### **6.1.1 Exemptions**

Facilities in which experimental or laboratory operations are conducted, and where no more than 200 grams (g) of explosives are involved, are exempt from site and construction plan preparation; however, adequate distance must be provided between the laboratory and other buildings containing explosives (with the distance based on the quantity of explosives in those buildings). Such operations include, but are not limited to, small-scale formulations work; chemical, physical, and thermal analysis; and sensitivity tests.

Experimental and laboratory facilities are exempt from Quantity-Distance (QD) criteria where operations involving 10 g or less of explosives are conducted under GRC Authority Having Jurisdiction (AHJ) approved SOPs. All explosives, propellants, and pyrotechnics—regardless of quantity—must be handled according to GRC's Chemical Hygiene Policy, as specified in Chapter 25 of the Occupational Health Programs Manual.

#### **6.1.2 Applicability**

When explosive quantities exceed the exempted amount for laboratory-scale operations (200 grams per location), Facility Explosive Site Plans, general construction plans for facilities or structures containing explosives, pyrotechnics, and propellants shall be prepared and reviewed by the ESO, the GRC AHJ for Fire Safety and the applicable Area Safety Committee for compliance with Section 4.25 of NASA Standard 8719.12. General details of the plans must include any non-related facilities, which may be exposed to the hazards of a potential explosion site. A facility site and construction plan shall show protection provided against explosion propagation between adjacent bays or buildings as well as protection of personnel against death or serious injury from incidents in adjacent bays or buildings.

If the protection of personnel and facilities would be greatly enhanced by having separate buildings sited to limit explosion propagation rather than by using protective construction and separation of explosive units within one building, then facility site planning should reflect this fact.

Sufficient protective construction should be provided to harden a Potential Explosive Site (PES) to suppress explosion effects. Proper location of the exposed site in relation to the PESs protects against unacceptable damage and injuries in the event of an accident. These factors may reduce the required QD when rationale or test results justify the reduction. This rationale must accompany the Facility Explosive Site Plan to be presented to the AHJ and SHeD and, when required, the NASA Headquarters Safety Office.

The ESO and AHJ approval must be obtained prior to initiating concept design for explosive facilities.

### **6.2 Operational Explosives Limits (NASA-STD-8719.12, Section 4A)**

The quantity of explosives at an operating location shall be the minimum necessary to carry out an operation in a safe and efficient manner. When practical, this quantity shall be subdivided and adequately separated to prevent propagation of detonation or deflagration. Supplies exceeding this minimum quantity shall be removed from the operating area. Maximum permitted quantity of explosives shall be displayed on all storage lockers or aboveground storage magazines. When necessary, Facilities may license a limited quantity, not to exceed 200 grams in each licensed location, of 1.1 Class/Division materials for research/testing in laboratories. A comparable quantity for the Class 1 Divisions (1.2, 1.3, 1.4, 1.5, and 1.6) is determined by the Trinitrotoluene (TNT) equivalency. A fragmentation barrier consisting of a 0.25 inch thick mild steel plate shall be used for storage. Explosives used solely for a research/testing project shall be licensed only for the length of the project.

### **6.3 Personnel Limits (NASA-STD-8719.12, Section 4B)**

The number of personnel at an explosive operating location shall be the minimum consistent with safe and efficient operation. The Area Safety Committee shall determine the minimum number of individuals permitted to perform explosives-related operations safely.

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#### 6.4 Limit Control (NASA-STD-8719.12, Section 4.C)

A barricading system shall be established during test operations to control entry of unauthorized personnel within explosives operating areas. The barricading distance shall be based on the QD, but it shall be set at intraline distance as a minimum.

#### 6.5 Training (NASA-STD-8719.12, Section 4F)

The SHed Training Committee, in cooperation with the ESO, shall establish a training and certification program for explosive handlers and awareness training for their immediate supervisors that shall be coordinated with operations personnel at LF and PBS. Training requirements are program specific. The explosive handler shall receive refresher training whenever the scope of his or her work changes, whenever the level of hazard changes, or every 3 years as a minimum.

#### 6.6 Medical Surveillance (Requirement (NPR) 1800.1 for Ordnance Handlers)

The onsite medical services contract will perform physical exams as required by NASA STD 8719.12 and NPR 1800.1 for ordnance handlers. Medical Services shall contact employees via letter notifying them they are due for their annual physical. It is the employee's responsibility to schedule and attend the physical. It is the responsibility of the employee's supervisor to ensure their employees attend and receive their physical. Medical Services will notify the employee and their supervisor in writing of their medical clearance status (by using the NASA GRC142 form). Supervisors are required to maintain this information in the employee's personnel records. Employees who are not current with the medical requirements cannot handle, use, or store explosives, pyrotechnics, or propellants. Offsite medical facilities may also perform testing but the requirements of 8719.12 and 1800.1 must be met. The exam requirements are as follows:

<b>L. Ordnance Handler</b>	
Reference	NPR 1800.1
Frequency	<ol style="list-style-type: none"> <li>1. Baseline Examination</li> <li>2. Annual Examination</li> </ol>
Laboratory	<ol style="list-style-type: none"> <li>1. Audiogram</li> <li>2. Visual Acuity</li> <li>3. Depth Perception</li> <li>4. Color Perception (as related to specific job requirements)</li> <li>5. Urinalysis (dipstick)</li> <li>6. Discretionary Tests: <ol style="list-style-type: none"> <li>a. ECG</li> <li>b. Complete Blood Count (CBC)</li> <li>c. Blood Chemistry Profile</li> <li>d. Chest X-ray</li> <li>e. Pulmonary Function</li> </ol> </li> </ol>
Physical Exam	<ol style="list-style-type: none"> <li>1. Medical and Occupational History to ascertain any condition that may cause any sudden incapacitation or inability to perform duties, tendencies to seizures, dizziness, claustrophobia, loss of physical control, or similar undesirable conditions</li> </ol>

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	2. Physical Examination focusing on strength, endurance, agility, coordination, adequate visual acuity and hearing, and emotional stability
Written Opinion	Job Certification with any limitations

## 6.7 Operating Procedures (NASA-STD-8719.12, Section 4G)

Operational procedures and check sheets shall be utilized when tests involving explosives are being performed. The operational procedure shall specify the step-by-step procedures for safe storage and handling, including any PPE required. The content of the operating procedures shall follow the written guidance contained in Chapter 4, paragraph 402, of the NASA-STD-8719.12.

## 6.8 New Explosives Facility Design and Construction (NASA-STD-8719.12, Section 4H)

New explosives facility building roofs and walls shall be designed to protect personnel and equipment by using fire walls, operational shields, substantial dividing walls, blast resistant roofs, containment structures, and earth-covered magazines in accordance with NASA-STD-8719.12. However, if an ordinary building is utilized and not specifically designed for explosives use, it shall be designed so that it is as light as practicable (weak) and so constructed and supported that it will vent an internal explosion with the formation of a minimum number of large fragments.

- **Fire Walls and Openings.**—Fire walls and openings in fire walls shall comply with requirements of local fire codes and associated NFPA standards.
- **Substantial Dividing Walls.**—Substantial dividing walls shall be designed in accordance with TM5–1300 or equivalent approved methods to prevent propagation of detonation by blast, fragmentation, or wall fragments. Openings in substantial dividing walls for any purpose are not recommended. When such openings are deemed necessary (e.g., to permit remote operation), the size shall not be larger than the minimum to permit safe passage of the item being transferred. When the opening is not in use, the opening shall be provided with closures designed to the level of protection afforded by the wall.
- **Operational Shields.**—Operational shields shall be designed for use in designated hazardous operations to provide protection to personnel, material, or equipment from the effects of a possible fire or explosion. The design of operational shields shall be in accordance with military standard (MIL–STD) 398 or TM5–1300. Operational shields to protect laboratory workers shall be in accordance with Table 5–5 of NASA-STD-8719.12.
- **Emergency Exits and Fire Escapes.**—As a minimum standard for GRC explosives-operating buildings and facilities, emergency exits and fire escapes shall follow the latest editions of NFPA 101 and the Ohio Basic Building Code.

### 6.8.1 Facility Explosive Site Plan Requirements (NASA STD 8719.12, Section 4.25.3)

- A facility site plan shall show protection provided against explosion propagation between adjacent bays or buildings and protection of personnel against death or serious injury from incidents in adjacent bays or buildings.
- If the protection of personnel and facilities would be greatly enhanced by having separate buildings sited to limit explosion propagation rather than using protective construction and separation of explosive units within one building, then facility site planning should reflect this fact.
- Safety approval of site plans shall be obtained from the ESO prior to initiating concept design and changes.

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- Site plans and changes to site plans shall be forwarded to the NASA Headquarters, Office of Safety and Mission Assurance, when required by Paragraph 4.25.2.3, after approval by the ESO.
- See Appendix A NASA 8719.12 which provides general guidance on content to be covered in the site plan.

#### **6.8.2 Licensed Explosive Locations (NASA-STD-8719.12, Section 4.25.9)**

Used for armories, ejection systems, and similar applications where explosives are used or stored for use. The requesting organization shall request the license in writing via the GRC Licensed Location Record for Explosives, Propellants, and Pyrotechnics (GRC4040) to the Center's ESO and revalidate the license annually.

Licenses shall be issued by the ESO for justification and based on an analysis and an operations review

Each individual license shall be signed by the requesting organization and coordinated by the GRC Chemical Hygiene Officer (CHO), the Office of Protective Services, and GRC Authority Having Jurisdiction (AHJ) prior to being approved by the ESO. The license shall be displayed at the licensed facility

#### **6.8.3 Hazardous Locations (NASA-STD-8719.12, Section 4B)**

Definitions of Class I, Class II, and Class III hazardous locations per NFPA 70, National Electrical Code (NEC), are defined as follows for NASA explosives facilities:

**Class I.**—Locations in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures

**Class I, Division 1.**—Locations where the hazardous atmosphere is expected to be present during normal operations

**Class I, Division 2.**—Locations in which volatile flammable liquids or gases are handled, processed, or used, but in which they will normally be confined within closed containers or closed systems from which they can escape only in the case of accidental rupture or breakdown of the container or system (The hazardous condition will only occur under abnormal conditions.)

**Class II.**—Locations that are hazardous because of the presence of combustible dust

**Class II, Division 1.**—Locations where combustible dust may be in suspension in the air under normal conditions in sufficient quantities to produce explosive or ignitable mixtures

**Class II, Division 2.**—Locations in which combustible dust will not normally be in suspension in the air, and normal operations will not put dust in suspension, but where accumulation of dust may interfere with the safe dissipation of heat from electrical equipment and may be ignited by arcs, sparks, or burning material from the equipment

**Class III.**—Locations that are hazardous because of the presence of easily ignitable fibers or flyings, but in which the fibers or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitable mixtures

**Class III, Division 1.**—Locations in which easily ignitable fibers or materials producing combustible flyings are handled, manufactured, or used

**Class III, Division 2.**—Locations where easily ignitable fibers are stored or handled

Where flammable or combustible gases are present, locations are classified as Class I locations if either a Division 1 or 2 situation can exist. Recognize that a Division 2 hazardous location normally exists in the vicinity of a Division 1 hazardous location.

Where explosives, propellants, or pyrotechnic dusts will be present, locations are classified as Class II locations if a Division 1 or 2 condition can exist.

#### **6.8.4 Equipment for Hazardous Locations (Article 500 of NEC)**

- Electrical equipment and its installation shall comply, as a minimum, with the requirements of the most recent edition of the NEC and OSHA, whichever is more restrictive (Requirement). The NEC, published by

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the NFPA as NFPA 70, does not address explosives specifically; however, Article 500 of the NEC, in its section on Hazardous (Classified) Locations, does establish standards for the design and installation of electrical equipment and wiring in atmospheres containing combustible dusts and flammable vapors and gases. NEC standards and this chapter are minimum requirements for NASA explosive facilities. The presence of hazardous energetic material may or may not result in the presence or creation of a hazardous atmosphere (combustible dust, flammable vapor or gas) with respect to electrical equipment or wiring, as defined in NEC (NFPA 70) Article 500.

## **6.9 Storage, Handling, and Disposal of Explosives (NASA-STD-8719.12, Section 4I)**

Hazardous energetic materials, including explosive and pyrotechnic materials, shall not be stored within an operating building except for the minimum quantities necessary to maintain individual operations. Supplies above this limit shall be kept in aboveground storage magazines located at an intraline distance (ILD) based on the net explosive weight of the explosives in the service storage magazine.

- A master list of all sites storing explosives and their locations, fire symbols, chemical storage sites, and available empty storage sites will be kept current and maintained by SHED. This list shall be available to emergency forces (e.g., local fire department and office of protective services) at all times.
- Explosives must be stored separately from other materials in laboratories. All explosives, exceeding exempted quantities, as well as other hazardous materials, must be stored outside laboratory buildings in separate facilities that meet construction and QD requirements.
- Where refrigeration is required for any flammable or explosive chemical, an explosion-proof mechanical refrigerator shall be used. Ventilation, as required, will be provided.
- Separate storage of flammable liquid fuels and oxidizers shall be in accordance with OSHA 1910, Subpart H—Hazardous Materials (Title 29 Code of Federal Regulations (CFR) 1910), as well as NFPA 50, 55, and 59A.
- Storage of small arms ammunition may be stored without regard to QD requirements provided that it is stored in a safe meeting Federal Specification AA-F-358H, Filing Cabinet, Legal and Letter Size, Uninsulated, Security, Class 5 or Class 6 and approved by the ESO.
- Storage rooms used for explosives shall be locked when unoccupied (Requirement)

### **6.9.1 Handling of Explosives (NASA-STD-8719.12, Section 4I)**

Explosives, propellants, and pyrotechnics shall be handled in accordance with technical operation manuals or written SOPs by properly trained personnel. Procedures shall identify the physical and health hazards associated with explosive composition, liquid propellants, or electro explosive devices; any unique storage and handling requirements; and any PPE required.

### **6.9.2 Disposal of Explosives (NASA-STD-8719.12, Section 4I)**

A sufficient number of proper containers shall be provided for various waste materials to preclude mixing materials that may result in a chemical reaction, fire, or explosion.

Storage and disposal shall follow established GRC waste management procedures to ensure compliance with environmental regulations in accordance with Chapter 5 of the Environmental Programs Manual.

Explosive materials that are considered serviceable can be excessed or turned over to another government agency at the discretion of the ESO so long as they are not deemed unserviceable.

## **6.10 Fire Protection (NASA-STD-8719.12, Section 5A)**

The GRC fire protection engineer, on the basis of maximum fire loss criteria and program mission interruptions and delays (risk analysis), shall determine the type of fire suppression system for operations with explosives or liquid propellants.

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- Fires involving explosives, propellants, and pyrotechnics will be fought according to their hazard division classification, the stage of the fire, and current procedures specified by the NASA organization concerned. Firefighting plans for explosives facilities will be prepared in advance and shall be developed by the user and approved by the GRC fire protection engineer.
- Field installations that rely on municipal or other fire-fighting organizations either on primary response or as a support unit will provide for hazard information or onsite meetings for fire fighters when requested to ensure the safety of the responding fire personnel.
- Vegetation around storage magazines and explosives-operating facilities should be controlled to minimize potential damage to the magazine or facility from grass, brush, or forest fires, or from erosion. A firebreak at least 15 meters wide and free from combustible material should be maintained around each aboveground magazine or facility processing or containing explosives. If the aboveground magazine or explosives facility exterior is fire resistant, the firebreak need not be devoid of vegetation, but growth must be controlled by mowing to prevent rapid transmission of fire to the magazine or facility. Maintenance of firebreaks around earth-covered magazines and cutting of grass covering these structures are not normally required, except around ventilators to prevent transmission of a fire into a structure.

#### 6.11 Electrical Equipment, Electromagnetic Radiation, Lightning Protection, and Static Electricity (NASA-STD-8719.12, Section 5B)

- **Electrical safety.**—Electrical equipment and its installation at NASA facilities shall comply, as a minimum, with the requirements of the most recent edition of the NEC and OSHA, whichever is more restrictive. NFPA 70E, Articles 500, 501, and 502 on hazardous (classified) locations, establishes standards for the design and installation of electrical equipment and wiring in atmospheres containing combustible dusts and flammable vapors and gases.
- **Electromagnetic radiation.**—Explosives or electro explosive devices shall not be exposed to direct electromagnetic radiation without a prior review by the GRC radiation safety officer.
- **Lightning protection.**—It is NASA policy to comply with the requirements of both NFPA 70 (NEC) and 780 to provide minimum criteria for the design of lightning protection systems for facilities involved in the development, manufacturing, testing, handling, storage, maintenance, and disposal of explosives, pyrotechnics, and propellants.
- **Static electricity.**—Static electricity shall be controlled to eliminate or mitigate a fire and explosion hazard in accordance with NFPA 77.
- **Explosives in Process During Electrical Storms:** Upon notification of an approaching electrical storm (lightning flashes observed or forecasted to be within 5 nautical miles of operation, or less if determined by local operational requirements), personnel shall be evacuated from facilities where there is an explosives hazard that could be initiated by lightning. Personnel shall be evacuated to an area that will provide protection commensurate with the hazard level. Explosive operations requiring attention at all times shall continue to be performed by the minimum number of personnel consistent with safety requirements. Any process involving explosives shall not be started unless absolutely necessary or unless the process can be completed prior to an anticipated storm. There is no guarantee that lightning protection systems will provide the same degree of safety as a lightning-free environment. Reference NASA STANDARD 8719.12 Section 5.12

#### 6.12 Laboratory Safety (NASA-STD-8719.12, Section 5C)

- The personnel limits and quantity of explosives used in any NASA laboratory must be established by the operating organization and approved by the responsible area safety committee. Where operations involve explosives, pyrotechnics, propellants, severe fire hazards, or toxic materials, personnel exposure must be limited to the minimum number of personnel, for the minimum time, consistent with safe and efficient operation.

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- Laboratory operations involving explosives shall be governed by an approved Safety Permit and SOPs for safe handling and must be separated from those laboratory processes not involving explosives by approved operational shields or barriers.
- Particularly hazardous laboratory operations involving explosives must be performed by remote control with the operator protected by an approved operational shield or barrier.
- Where refrigeration is required for any flammable or explosive chemical, an ice chest of approved design or explosion-proof mechanical refrigerator shall be used. Ventilation, as required, will be provided.
- Liquid propellants or their constituents having flammable, corrosive, or toxic properties shall be stored and handled according to OSHA 1910.1450 and the GRC Chemical Hygiene Plan.

### 6.13 Concurrent Hazardous Operations (NASA-STD-8719.12, Section 5D)

Unless a building or facility is specifically designed in accordance with TM5–1300 for concurrent operations, permissible concurrent operations should be conducted in separate buildings located at the appropriate intraline distance from other operating buildings. When it becomes necessary to conduct concurrent operations in the same building, the operational layout will be planned to segregate the primary hazards by substantial dividing walls, barricades, or other means to ensure maximum personnel protection.

### 6.14 Housekeeping (NASA-STD-8719.12, Section 5E)

Good housekeeping must be practiced at all times. Each laboratory or room must be kept neat, orderly, and free of hazardous amounts of explosives and chemical contamination. Corridors must be kept clean; floors, shelves, and work areas shall be kept free from all unnecessary apparatus and chemicals. Spills shall be cleaned up immediately, and broken glassware shall be placed in separate, specially marked receptacles.

### 6.15 Personal Protective Equipment (NASA-STD-8719.12, Section 5F)

Based on a worksite hazard assessment, personal protective equipment will be issued to employees in those situations where engineering controls, management controls, or other corrective actions have not reduced the hazard to an acceptable level or where use of engineering controls, management controls, or other techniques is not feasible.

### 6.16 Prohibited Articles in Hazardous Areas (NASA-STD-8719.12, Section 5E)

Personnel shall not be permitted to carry cigarette lighters, matches, or any other flame-producing devices into hazardous materials restricted areas.

### 6.17 Tooling and Equipment (NASA-STD-8719.12, Section 5F)

Only non-sparking intrinsically safe tools will be used in locations where sparks may cause a fire or explosion, example, e.g., for work in locations that contain exposed explosives or hazardous concentrations of flammable dusts, gases, or vapors.

### 6.18 Parking (NASA-STD-8719.12, Section 5.9.1)

Parking of privately operated vehicles (POV) shall be controlled to minimize fire and explosive hazards and prevent congestion in the event of emergency. (Requirement) Automobiles shall be parked in designated areas outside of restricted areas. They should not be parked close enough to a building to either enable the spread of fire from an automobile to the building or hinder access by firefighters. Parking areas for privately owned vehicles shall be separated from a PES by 100 foot minimum distance if they serve only the workers assigned to a single PES and ILD from all other PESs (Requirement). If they serve multiple PESs, the minimum distance shall be ILD (Requirement). Private vehicle parking in administrative areas shall be a minimum of public traffic route distance from the nearest PES (Requirement). Minimum fragment distance shall be maintained in all situations except for POV parking areas serving a single PES (Requirement). The local ESO may reduce these parking requirements for licensed facilities.

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## 6.19 Rocket Catapults and Explosive Release Cartridges for Aircraft Ejection Seats (NASA-STD-8719.12, Section 4.25.9.1.12.5.2)

The GRC Chief of the Aircraft Operations Office shall be responsible for managing the storage, handling, and disposal of aircraft ejection seat explosive devices in accordance with this chapter or aircraft technical manuals for Class 1.4 explosive release devices and Class 1.3 rocket catapults.

## 6.20 Explosives, Propellants, and Pyrotechnics Hazard Classification (NASA-STD-8719.12, Section 5H)

The explosive hazard classification system consists of six hazard divisions for dangerous goods with ammunition and explosives included in United Nations Organization Class 1, Explosives. These ammunition and explosives hazard divisions are based on the character and predominance of the associated hazards and the potential for causing personnel casualties or property damage.

### 6.20.1 Explosives and Pyrotechnics Hazard Classification

- **Division 1.1.**—These explosives have a mass-detonation explosion hazard. Items in this division are primarily a blast hazard and may be expected to mass detonate when a small portion is initiated by any means. This division includes bulk explosives and some propellants.
- **Division 1.2.**—These explosives have a projection hazard, but not a mass explosion hazard. (Items in this division are not permitted at GRC.)
- **Division 1.3.**—These explosives have a fire hazard and either a minor blast hazard, minor projection hazard, or both, but do not have a mass-explosion hazard. Items in this division burn vigorously with little or no chance of extinguishment in storage configurations. Explosions normally are confined to pressure ruptures of containers and will not produce propagating shock waves or damaging blast overpressures beyond the magazine distances specified in Table 8–3 of NASA-STD-8719.12. A severe hazard of the spread of fire may result from tossing about the burning container materials, propellant, firebrands, or other debris. Toxic effects usually do not go beyond inhabited building distances. This division includes items such as solid propellant compositions.
- **Division 1.4.**—These explosives present a minor explosion hazard. The explosive effects are largely confined to the package and no projection of fragments is expected. An external fire must not cause instantaneous explosion of almost the entire contents of the package. Items in this division present a fire hazard with no blast hazard and virtually no fragmentation hazard beyond the fire hazard clearance ordinarily specified for high-risk materials. Separate facilities for storage and handling of this division should not be less than 100 foot from other facilities, except those of fire-resistive construction, which may be 50 foot from each other. This division includes items such as small arms ammunition without explosive projectiles, fuse lighters and squibs, colored smoke grenades, and explosive valves or switches.

### 6.20.2 Liquid Propellants Hazard Classification (NASA-STD-8719.12, Section 5H)

Hazard Classification of Energetic Liquids.

The main hazard classification designator for energetic liquids is Class 1 (explosives), Class 2 (compressed or liquefied gases), Class 3 (flammable liquids), Class 4 (flammable solids, self-reactive materials), Class 5 (oxidizers), Class 6 (toxic/infectious substances), Class 7 (radioactive), Class 8 (corrosive), or Class 9 (miscellaneous).

The standard storage and transportation compatibility designation is the (CG or SCG) designation. The alpha designations are the same as the CG designations for UN Hazard Class 1, with the same definitions. However, for storage and handling on NASA facilities, a CG may also be assigned to an energetic liquid in a Hazard Class other than Class 1. The absence of a CG indicates incompatibility with solid explosives.

Energetic Liquid Compatibility Group (ELCG) designation. The ELCG applies to mixed storage of energetic liquids or explosives components containing energetic liquids. The ELCG is specified in parentheses as the last element of the hazard classification. The ELCG designations and definitions are:

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- LA - Energetic liquids that are strong oxidizers, mainly of acidic character. These materials may cause or contribute to the combustion of other material, possibly resulting in serious flare fires or explosions. Includes, but is not limited to, nitrogen tetroxide and mixed oxides of nitrogen (MON), inhibited red fuming nitric acid (IRFNA), liquid oxygen (LO2), hydrogen peroxide (H2O2), and gels, slurries, or emulsions of the above.
- LB - Energetic liquids that are readily combustible when exposed to, or ignited in the presence of an oxidizing agent, but that are not strong reducing agents. Some may be hypergolic with group LA materials. Includes, but is not limited to, hydrocarbons such as kerosenes and strained ring ramjet fuels; liquid hydrogen (LH2); and gels, slurries, or emulsions of the above.
- LC - Energetic liquids that are readily combustible when exposed to, or ignited in the presence of an oxidizing agent, and are also strong reducing agents. These will likely be hypergolic with group LA substances. Includes, but is not limited to, hydrazines and other amines; and gels, slurries, or emulsions of the above.
- LD - Energetic liquids that act mainly as combustible fuels, similar to groups LB and LC, when exposed to, or ignited in the presence of oxidizing agents but that may act as oxidizers in some combinations. They may be a monopropellant with the right catalyst, or may be pyrophoric and ignite upon release to the atmosphere. Examples are ethylene and propylene oxides, and boranes.
- LE - Energetic liquids having characteristics that do not permit storage with any other energetic liquid. They may react adversely with either fuels (reducing agents) or oxidizers. Examples are nitromethane, nitrate ester based formulations such as Otto Fuel II, liquid monopropellants containing hydroxyl ammonium nitrate (HAN), halogen fluorides (ClF3 and ClF5) and fluorine, and gels, slurries, or emulsions of the above.

Different energetic liquids in the same ELCG may be stored together with the exception of dissimilar liquids of Group LE. Mixed storage is prohibited between energetic liquids of different ELCG designations, with one exception: liquids of groups LB and LC should not be stored together if possible, especially for storage areas containing primarily materials of group LB; however, mixed storage is permitted if circumstances dictate. This compatibility scheme is reflected in the hazard classification for the hydroxyl ammonium nitrate based liquid propellant XM-46: 1.3C(LE). This hazard classification reflects CG "C" which indicates the propellant can be stored in the same magazine with CG "C" solid propellants, and since CG "C" can be mixed in storage with CG "D" (see Table XI), CG "D" high explosive projectiles could also be present. On the other hand, hydrocarbon fuel such as JP-10 would not be permitted in this storage scenario, because its ELCG (LB) indicates incompatibility with the liquid gun propellant (LE).

- Hazard classification for NASA energetic liquids is shown in Table XXIX of NASA Standard 8719.12
- Liquid Propellant volume to weight conversion factors for typical propellants can be found in Table XXX of Section 5.51 of NASA Standard 8719.12.
- Liquid Propellant explosive equivalent weights for various fuels/oxidizer combinations can be found in Table XXXI of Section 5.51 of NASA Standard 8719.12.
- Flammable liquids, used as a propellant, that are stored separate from oxidizers shall be stored according to NFPA requirements.

### 6.20.3 Hazard Division 1.1 through 1.6, Storage Compatibility Groups (SCGs)

In accordance with explosives storage principles and considerations for mixed storage, explosives are assigned to one of the following 12 SCG's.

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- Group A. Initiating explosives - Bulk initiating explosives that have the necessary sensitivity to heat, friction, or percussion to make them suitable for use as initiating elements in an explosive train. Examples are wet lead azide, wet lead styphnate, wet mercury fulminate, wet tetracene, and dry pentaerythritol tetranitrate (PETN).
- Group B. Detonators and similar initiating devices - Items containing initiating explosives that are designed to initiate or continue the functioning of an explosive train. Examples are detonators, blasting caps, small arms primers, and safe/arm without two or more safing-features.
- Group C. Bulk propellants, propelling charges, and devices containing propellant with or without their own means of ignition - Items that upon initiation will deflagrate, explode or detonate. Examples are single, double, triple-base, and composite propellants, rocket motors (solid propellant).
- Group D. Black powder, a high explosive (HE), or a device containing an initiating explosive and two or more independent safety features - Explosives that can be expected to explode or detonate when any given item/component thereof is initiated.
- Group E. Ammunition containing high explosive (HE) without its own means of initiation and containing or with propelling charge (other than one containing a flammable or hypergolic liquid). Examples are artillery ammunition, rockets, or guided missiles.
- Group F. Devices (fused) with or without propelling charges. Examples are sounding devices and similar items having an in-line explosive train in the initiator.
- Group G. Fireworks, illuminating, incendiary, and smoke devices. (Not normally found in NASA installations).
- Group H. Ammunition containing both explosives and white phosphorous or other pyrophoric material. Ammunition in this group contains fillers which are spontaneously flammable when exposed to the atmosphere. (Not normally found in NASA installations).
- Group J. Ammunition containing both explosives and flammable liquids or gels. Ammunition in this group contains flammable liquids or gels other than those which are spontaneously flammable when exposed to water or the atmosphere. (Not normally found in NASA installations).
- Group K. Ammunition containing both explosives and toxic chemical agents. (Not normally found in NASA installations).
- Group L. Devices not included in other compatibility groups - Devices having characteristics that do not permit storage with other types of material. Examples are water-activated devices, prepackaged hypergolic liquid-fueled rocket engines, fuel-air explosive devices (FAE), (thickened Triethyl Aluminum (TEA)), and damaged or suspect items of any group. Types preventing similar hazards (i.e., oxidizers with oxidizers, fuels with fuels, etc.) may be stored together but not mixed with other groups.
- Group N. Hazard Division 1.6 devices containing only extremely insensitive detonating substance (EIDS). If dissimilar Group N explosives are mixed together and have not been tested to assure non-propagation, the mixed explosives are considered to be Hazard Division 1.2, Compatibility Group D, for purposes of transportation and storage.
- Group S. Items presenting no significant hazard — Devices so designed or packed that when in storage all hazardous explosive effects are confined and self-contained within the item or package. An incident may destroy all items in a single pack, but must not be communicated to other packs so all are

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destroyed. Examples are thermal batteries, explosive switches or valves, Safe and Arming (S&A) devices, and other items packaged to meet the criteria of this group.

#### **6.20.4 Mixed Storage (NASA-STD-8719.12, Section 5H)**

Mixing of storage compatibility groups is permitted as indicated in Figure 6–2 and Table 6–1 of NASA-STD-8719.12. Items from storage compatibility groups C, D, F, G, and S may be combined in storage if the net quantity of explosives in the items or in bulk does not exceed 1000 pound per storage site. These items must be packaged in accordance with approved drawings.

#### **6.21 Quantity Distance Requirements (NASA-STD-8719.12, Section 5I)**

The location of explosives facilities with respect to each other and to other exposures shall be based on the total quantity of explosives in each facility. When the total quantity is so subdivided that an incident involving any of the subdivisions will not produce simultaneous initiation of others, the net explosive weight of the mass-detonating explosives in the largest subdivision shall apply. Applicable QD tables for explosives and liquid propellants follow and are contained in NASA-STD-8719.12.

#### **6.22 Transportation, Materials Handling Equipment, And Shipment of Explosives, Propellants, and Pyrotechnics (NASA-STD-8719.12, Section 5J)**

##### **6.22.1 Transportation**

The transportation of explosives by rail, air, vessel, and public highway shall comply with Department of Transportation regulations in 49 CFR Sections 173.52, 174.81, 175.78, 176.83, and 177.84. Transportation of explosives, propellants, or pyrotechnics onsite at LF or PBS must be with a dedicated Government vehicle. Personal vehicles may not be used to transport explosives.

##### **6.22.2 Material-Handling Equipment**

Material-handling equipment used for moving explosives, propellants, or devices containing explosives shall meet requirements specified by OSHA or NFPA based on the area hazard classification.

##### **6.22.3 Shipment of Explosives**

- **Purchasing Explosives**  
All explosive purchases shall be approved by the GRC Chemical Hygiene Officer and the ESO within SHed to ensure that adequate facilities exist for storage.
- **Packaging Regulations**  
The general regulations governing the marking, packing, and shipping of explosives are set forth in DOT 49 CFR and International Air Transport Association (IATA) regulations.
- **Electrostatic Packaging Materials.**  
In packaging explosives and explosive items for shipment, personnel will utilize all of the available technology and information to determine packaging materials, such as, antistatic packaging that will minimize triboelectric and frictional charging with proper conductivity to permit a safe, slow distribution of generated charge. Correct use of these guidelines will almost eliminate the possibility of electrostatic discharge (ESD) in explosive packaging material.
- **Receiving Explosives.**  
When explosives are received at GRC's LF and PBS, the requester or purchaser of explosives or propellants must specify on the purchase order (1) The proper shipping name and United Nations Organization number, (2) the explosive hazard division, and (3) storage compatibility. In addition, the requester's or purchaser's full name, phone number, and delivery location must be on the shipper's invoice so that the shipper can transport the explosives to the approved storage location upon arrival at GRC. The requestor, purchaser or designated individual must be present to receive the material and ensure that it is properly stored.

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## 6.23 Explosion Hazards and Exposure Risk Management (NASA-STD-8719.12, Section 5K)

In the assessment of the hazard associated with explosions, the principal effects of the explosive output to be considered are blast pressure, primary and secondary fragments, thermal hazards, and toxicity hazards. As an alternative to using the Quantity-Distance (QD) tables in the NASA Standard- 8719.12, reduced distances can be utilized if supported by testing/analyses of blast, fragment, and the thermal exposure criteria contained in DoD 6055.9E. These reduced distances shall be approved by the Explosive Safety Officer. A general discussion concerning the effects of blast waves, fragmentation, and thermal hazards is contained in Section 5.63 of NASA Standard- 8719.12 and DoD Standard 6055.9E. Any toxic material must be analyzed using dispersion analysis if there is risk to other GRC employees, the environment or the local community in the event of a release.

## 7.0 RECORDS

### 7.1 Explosives Inventory (NASA-STD-8719.12, Section 4D)

Authorized handlers of explosives at GRC at LF and PBS shall maintain a current inventory of explosives under their control. The inventory listing shall be located at the explosive storage magazine, laboratory or earth covered magazine where explosives are stored. The inventory shall be updated by the user when explosives are removed or added to the inventory and audited annually by the ESO. A copy of the inventory shall be forwarded to the Chemical Hygiene Officer when explosives are added or removed.

The ESO shall perform an annual survey for explosive materials located at GRC and PBS and provide a copy to the Chemical Hygiene Officer. Copies will be provided to SHED management and hard copies will be maintained by the ESO. Due to security requirements the explosive inventory shall be considered a sensitive document.

### 7.2 Training Records (NASA-STD-8719.12, Section 4F)

Training records for explosive handlers shall be maintained by each individual's company or organization. Copies of explosive handler's training and certification shall be attached to the GRC580, qualified operator's list of the associated safety permit for operations involving explosives or propellants. The onsite security contractor shall maintain training records for all security officers.

## 8.0 REFERENCES

### 8.1 Department of Defense References

Document number	Document name
DoD Directive <b>6055.9E</b>	Explosives Safety Management and the DoD Explosives Safety Board (2005).
DoD STD <b>6055.9-M</b>	Department of Defense: DoD Ammunition and Explosives Safety Standards. (Volumes 1-8).
MIL-STD- <b>398A</b>	Shields, Operational for Ammunition Operations, Criteria for Design of and Tests for Acceptance, (2014).
UFC 3-340-02	Structures to Resist the Effects of Accidental Explosions (2008).

### 8.2 Department of Energy References

Document number	Document name
DOE-STD-1212-2012	Department of Energy (DOE), Explosive Safety Manual (2012)

### 8.3 Occupational Safety and Health Administration References

Document number	Document name
29 CFR <b>1910.103</b>	Occupational Safety and Health Standard, Hazardous Materials, Hydrogen.

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- 29 CFR **1910.104** Occupational Safety and Health Standard, Hazardous Materials, Oxygen.
- 29 CFR **1910.109** Occupational Safety and Health Standard, Hazardous Materials, Explosives and Blasting Agents.
- 29 CFR **1910.110** Occupational Safety and Health Standard, Hazardous Materials, Storage and Handling of Liquefied Petroleum Gases.

#### **8.4 Department of Transportation References**

- | <b>Document number</b> | <b>Document name</b>  |
|------------------------|---|
| 49 CFR <b>171–179</b>  | Department of Transportation Regulations Chapter I, Subchapter C, Hazardous Materials, Regulations. |

#### **8.5 Environmental Protection Agency References**

- | <b>Document number</b> | <b>Document name</b>  |
|------------------------|---|
| 40 CFR <b>261</b>      | Protection of Environment, Solid Wastes, Identification and Listing of Hazardous Waste. |

#### **8.6 National Aeronautics and Space Administration References**

- | <b>Document number</b>         | <b>Document name</b>  |
|--------------------------------|---|
| NASA-STD- <b>8719.12 Rev.2</b> | Safety Standard for Explosives, Propellants, and Pyrotechnics (2011). |
| NPR <b>8715.3C</b>             | NASA General Safety Program Requirements (2008).                      |
| NASA–STD– <b>8719.11 Rev.A</b> | Safety Standard for Fire Protection (2008).                           |

#### **8.7 National Fire Protection Association References**

- | <b>Document number</b> | <b>Document name</b>   |
|------------------------|--|
| NFPA 30                | Flammable and Combustible Liquids Code.  |
| NFPA 45                | Standard on Fire Protection for Laboratories Using Chemicals.                                  |
| NFPA 50                | Standard for Bulk Oxygen Systems at Consumer Sites.  |
| NFPA 55                | Standard for the Storage and Handling of Compressed and Liquefied Gases in Portable Cylinders. |
| NFPA 59A               | Standard for Production, Storage and Handling of Liquefied Natural Gas (LNG).                  |
| NFPA 70                | National Electrical Code.  |
| NFPA 77                | Recommended Practice on Static Electricity.  |
| NFPA 780               | Standard for the Installation of Lightning Protection Systems.                                 |

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## APPENDIX A.—DEFINITIONS AND ACRONYMS

**Aboveground storage magazine.**—Any building or structure, except for an operating building, used for the storage of explosives. Aboveground magazines are all types of above-grade (not earth covered) magazines or storage pads. This includes storage in trucks, trailers, railcars, or cargo aircraft.

**American Institute of Aeronautics and Astronautics (AIAA)**

**American National Standards Institute (ANSI)**

**Antistatic.**—Materials that exhibit a surface resistivity greater than  $10^9 \, \Omega \cdot \text{m}^2$ , but less than  $10^{14} \, \Omega \cdot \text{m}^2$ . This implies that the material does not exhibit triboelectric-charging propensities. This is unusual because of the topical treatment or volume impregnation of the material with a surfactant.

**Authority having jurisdiction.**—Individual appointed by the Chief of the Safety, Health and Environmental Division to be responsible for ensuring that explosive-related operations conducted at GRCs LF and PBS is conducted in accordance with all Federal, State, local and NASA requirements.

**Barricade.**—Intervening approved barrier, natural or artificial, of such type, size, and construction as to limit, in a prescribed manner, the effect of an explosion on nearby buildings or exposures.

**Code of Federal Regulations (CFR)**

**Compatibility.**—Chemical property that allows materials to coexist without adverse reaction for an acceptable period of time. Compatibility exists in storage when storing materials together does not increase the probability of an accident or, for a given quantity, the magnitude of the effects of such an accident. Storage compatibility groups are assigned to provide for segregated storage.

**Concurrent operations.**—Operations performed simultaneously and in close enough proximity that an incident with one operation could adversely influence the other.

**Deflagration.**—Rapid chemical reaction in which the output of heat is sufficient to enable the reaction to proceed and be accelerated without the input of heat from another source; a surface phenomenon with the reaction proceeding toward the un-reacted material along the surface at subsonic velocity. The effect of a true deflagration under confinement is an explosion. Confinement of the reaction increases pressure, rate of reaction, and temperature and it may cause transition into a detonation.

**Department of Defense (DoD)**

**Detonation.**—Violent chemical reaction within a chemical compound or mechanical mixture evolving heat and pressure that proceeds through the reacted material toward the un-reacted material at a supersonic velocity. The chemical reaction exerts an extremely high pressure on the surrounding medium, forming a propagating shock wave that starts at a supersonic velocity. When the material is located on or near the surface of the ground, a detonation is normally characterized by a crater.

**Earth-covered magazine.**—Above ground, earth-covered structure intended for the storage of explosives, pyrotechnics, propellant, or United Nations Organization Class 1 hazardous materials and that meets the soil cover depth and slope requirements of NASA STD 8719.12.

**Electroexplosive device.**—Device containing some reaction mixture (explosive or pyrotechnic) that is electrically initiated. The output of the initiation is heat, shock, or mechanical action.

**Electrostatic discharge.**—Arcing of electric charge across a gap between two points not in contact or through a nonconductor when the voltage exceeds the dielectric breakdown voltage of the nonconductor. All static electricity hazards are initiated by this sudden energy release or discharge mechanism.

**Energetic liquid.**—Liquid, slurry, or gel consisting of, or containing, an explosive, oxidizer, fuel, or combination of the above, that may undergo, contribute to, or cause rapid exothermic decomposition, deflagration, or detonation.

**Explosive wastes.**—Explosive materials or devices that are no longer useable or no longer wanted or needed and have no intended use (see 40 CFR 261).

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**Explosives.**—Any chemical compound or mechanical mixture that, when subjected to heat, impact, friction, detonation, or other suitable initiation, undergoes a very rapid chemical change with the evolution of large volumes of highly heated gases that exert pressures in the surrounding medium. The term applies to materials that either detonate or deflagrate.

**Exposed site.**—Location exposed to the potential hazardous effects (blast, fragments, debris, and heat flux) from an explosion at a potential explosive site.

**Flyings.**—Lightweight airborne particles.

#### **Glenn Research Center (GRC)**

**High explosive.**—Explosive in hazard division 1.1 through 1.6 that, once initiated, transforms with virtually instantaneous and continuous speed through the total mass, accompanied by the rapid evolution of a large volume of gas and heat, causing very high pressure and a widespread shattering effect.

**Hypergolic.**—Self-igniting upon contact of the fuel and oxidizer, without a spark or external aid.

**Inhabited building distance.**—Minimum allowable distance between an inhabited building and an explosive facility. Inhabited building distances are used between explosives facilities and administrative areas, operating lines with dissimilar hazards, explosive locations and other exposures, and explosive facilities and installation boundaries.

**Inhabited building.**—Building or structure—other than operating buildings, magazines, and auxiliary buildings—occupied in whole or in part by human beings, or where people are accustomed to assemble—both within and outside of Government establishments. Land outside the boundaries or local restrictive easement estate of NASA establishments shall be considered as inhabited buildings (Requirement).

**Intraline distance (ILD).**—Minimum distance permitted between any two buildings within one operating line. Intraline distances are also used for separating certain specified areas, buildings, magazines, aircraft, and other locations even though actual line operations are not involved. Intraline distance separation is expected to protect explosive materials in buildings from propagation detonation due to blast effects, but not from the possibility of propagation detonation due to fragments. Buildings separated by intraline distances will probably suffer substantial structural damage.

**Laboratory operation.**—Operation in a laboratory where the total quantity of explosives in the facility does not exceed 500 g.

#### **Liquefied natural gas (LNG)**

**Magazine.**—Structure designed or specifically designated for the storage of explosives.

**Magazine distance.**—Minimum distance permitted between any two storage magazines. The distance required is determined by the type(s) of magazine and also the type and quantity of explosives stored therein.

**Mass detonation or explosion.**—Virtually instantaneous explosion of a mass of explosives when only a small portion is subjected to fire, severe concussion or impact, the impulse of an initiating agent, or to the effect of a considerable discharge of energy from an outside stimulus.

#### **Military standard (MIL STD)**

#### **NASA Procedural Requirement (NPR)**

#### **NASA Safety Standard (NASA-STD-)**

#### **NASA Standard (NASA STD)**

#### **National Electrical Code (NEC)**

#### **National Fire Protection Association (NFPA)**

**Net explosive weight.**—Total quantity, expressed in pounds, of explosive material or pyrotechnics in an item.

**Occupational Safety and Health Administration (OSHA)**

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**Operating building.**—Any structure, except a magazine, in which operations pertaining to manufacturing, processing, or handling explosives are performed.

**Operational shield.**—Barrier constructed to protect personnel, material, or equipment from the effects of a possible fire or explosion occurring at a particular operation.

#### **Personal protective equipment (PPE)**

#### **Plum Brook Station (PBS)**

**Potential explosive site (PES).**—Location of a quantity of explosives that will create a blast fragment, thermal, or debris hazard in the event of an accidental explosion of its contents.

**Propellant, liquid.**—Substances in fluid form (including cryogenics) used for propulsion or operating power for missiles, rockets, and other related devices (see Table XXIII of NASA-STD-8719.12). For the purpose of this chapter, liquid fuels and oxidizers are considered to be propellants even when stored and handled separately.

**Propellant, solid.**—Explosives compositions used for propelling projectiles and rockets and to generate gases for powering auxiliary devices.

**Public traffic route distance.**—Distance to be maintained between a potential explosion site and any public street, road, or highway, navigable stream, or passenger railroad (includes roads on NASA field installations that are open to the public for thoroughfare).

**Pyrotechnic device.**—Manufactured device or article containing pyrotechnic material(s). Common pyrotechnic devices include road flares, marine distress signals, and smoke grenades. Pyrotechnic devices may contain other explosive materials in addition to pyrotechnic materials.

**Pyrotechnic material.**—Explosive or chemical ingredients, including powdered metals, used in the manufacture of pyrotechnic devices.

**Quantity-Distance (QD).**—Quantity of explosives and distance separation relationships that provide defined types of protection. These relationships are based on levels of risk considered to be acceptable for the stipulated exposures and are tabulated in the appropriate QD tables.

**Restricted area.**—Area, usually fenced, at an establishment where the entrance and egress of personnel and vehicular traffic are controlled for reasons of safety.

**Rocket.**—Complete device that derives its thrust from ejection of hot gases generated from propellants carried in the vehicle.

#### **Safety and Health Division (SHeD)**

**Service storage magazine.**—Auxiliary building used for the intermediate storage of explosive materials not exceeding the minimum amount necessary for safe efficient production.

**Simultaneous detonation.**—Detonation of separated quantities of explosives occurring so nearly at the same time that the effect on the surroundings is the same as if the several quantities were not separated and were mass detonated.

#### **Standard operating procedure (SOP)**

**Static test stand.**—Locations on which liquid propellant engines or solid propellant motors are tested in place.

**Storage compatibility.**—Relationship between different explosives and other dangerous materials such that storing or transporting two or more of the items together is no more hazardous than storing or transporting a comparable quantity of any one of the items alone.

**Storage magazine.**—Structure designed or specifically designated for the long-term storage of explosives or ammunition.

**Substantial dividing wall.**—Interior wall designed to prevent simultaneous detonation of quantities of explosives on opposite sides of a wall.

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### **Trinitrotoluene (TNT)**

**TNT equivalent.**—Measure of the blast effects from an explosion of a given quantity of material expressed in terms of the weight of TNT that would produce the same blast effects when detonated.

**Triboelectric charge.**—Electrical charge produced by friction between two nonconductive materials.

**Waiver.**—Document that authorizes departure from a specific performance or operational requirement for a specified mission or period of time.

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